Making a Toy Educative Using Electronics

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Abstract. We present building blocks equipped with electronics for educational purposes. The blocks have changeable colors, a simple LED screen, and a mechanism for decentralized communication between blocks that touch each other. Using these simple elements, we introduced functionality to implicitly support the development of *prenumerical skills* of preschool children without detracting from the primary value of the toys: building towers and structures of blocks.

1 Introduction

When designing an educational toy there is a basic decision between the design of a new, dedicated toy that focusses on a learning objective, or the design of a regular toy in which the educational content comes in addition to a well proven playing aspect.

We discuss how we equipped robust *building blocks* with technology to implicitly support development of prenumerical skills in preschool children (aged 5-6), in such a way as to not interfere with the basic play functionality of the blocks. Usability was a key concern, not only for the children but also for the teachers who have to work with the blocks. We aim at simple, off-the-shelf usability, without the need for a central server PC, and no complicated installation or configuration processes. The toy is implemented in such a way that it is feasible to make it into a commercial product. This includes aspects such as robustness, battery life, producability and manufacturability. The various elements of the design should lend themselves to large scale manufacturing and the components should be affordable.

2 Related Work

Playing blocks and electronics are a popular combination in related research. Here, we discuss a small, representative collection of related work.

TileToy[1] — TileToys are a dynamic, electronic platform for tangible LED games. They consist of tiles with a LED matrix to display simple images and shapes, communicating with each other by wireless radio through a host computer. Various games such as word games and jigsaw games are available.

[1] http://tiletoy.org

A. Nijholt, T. Romão, and D. Reidsma (Eds.): ACE 2012, LNCS 7624, pp. 477–480, 2012.
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The authors also describe a game in which the tiles show numbers and have to be grouped in order to sum up to a desired outcome.

MB Led[2] — The MB Led toy originated from the idea to create a dynamic jigsaw, where an animation instead of a static picture has to be formed. The difference with TileToy is that communication is done through IrDA transceivers at the edges and therefore does not rely on a host computer, and that a speaker is included. Games available include a dynamic puzzle, a snake game where the tiles need to be repositioned in order to avoid the snake touching an edge and a tetris game where the falling blocks are controlled by blocks at the sides.

Siftables [**3**] — Siftables are square tiles with a graphical display instead of a LED matrix, which allows for more flexible visualization. Interaction with Siftables relies on gestures such as shaking and tilting, in addition to the 2D layout of the blocks next to each other. Communication is also through IrDA transceivers at the edges of blocks. The flexibility of the product has led to a huge variety of mostly educational applications.

Interactive Tiles [**4**] — "Interactive Tiles" are toys for children about 3-4 years old. Their goal is to encourage and support social interaction between playing children. The toys are robust tiles with different colors lighting built in. The different colors are activated by applying different pressures on the tile. Tiles can be combined to build stacks, pathways, floors, etc. An important aspect of the design is the fact that there are no predefined game rules imposed on the children. All 'games' that the children played with the tiles emerged naturally from their playful exploration of the possibilities of the tiles.

3 Design

We chose to work in the area of mathematical skills. The mathematical ideas that preschool children are taught are called "pre-numerical skills", and can be classified in awareness of numbers and counting, quantities and quantity-in-variety ("two half cookies are not more cookie than one whole cookie"), sorting and grouping, series, memory, and spatial vision [2].

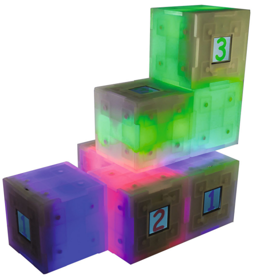
It has been shown that realistic objects motivate children to reenact real-life scenarios, whereas geometric objects encourage abstract thinking [1]. We chose to work with *building blocks* (abstract geometrical objects such as cubes, cuboids, cylinders, arcs, and triangular prisms), because they are popular, well known and understood, can be used in large amounts at the same time (useful to present quantities), are rearranged frequently (useful for sorting and grouping concepts), and are large enough to fit electronics.

The concept of quantities and of classification/grouping are very important for children at this age. Quantities are of course very easy to emphasize with *blocks as units*. Our blocks can change color, which makes it possible to distinguish blocks from each other, better facilitating concepts of classification and

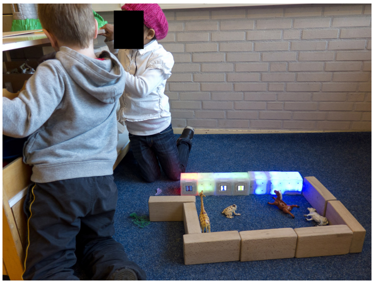
[2] `http://mbled.wordpress.com/`

grouping. Detecting when blocks form a group requires "neighbor sensing" and communication between the blocks. The blocks can deliver feedback in various ways. They can signal "right or wrong" (e.g., activated/not activated). They can also "point out information", by showing a number on a screen denoting the sum of all blocks connected in a group.

Fig. 1 shows a photo of our prototypes. They are cubic in shape, because this yields the most possibilities in building structures, and are about 6x6x6 cm. The blocks are semi-transparent and can shine in different colors. Tapping a block will make it change color. All blocks are equipped with a display. This display always shows the number of blocks grouped together with the same color. Groups are formed by blocks of the same color, partially or fully connected to each other (side by side or stacked, see Fig. 1(a)).



(a) Stacked and grouped



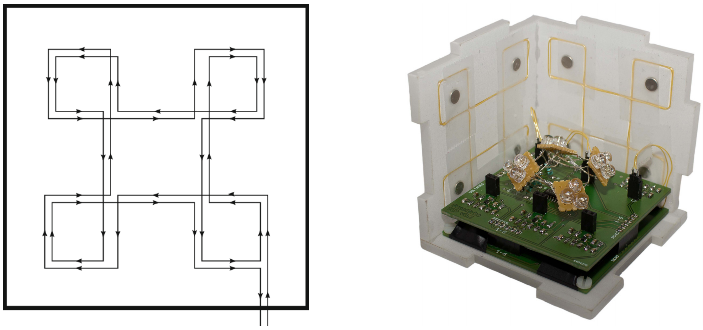
(b) Pre-school children playing with the blocks

Fig. 1. The prototype blocks

4 Implementation

The electronic system consists of microcontroller, communication system, tap and orientation sensing, RGB LEDs, LCD display and power section. The blocks are controlled by an Atmel AVR series microcontroller.

A contact detection mechanism and protocol has been developed that allows for detecting not only when blocks are fully aligned, as with the IrDA solutions of related systems, but also when blocks are connected only on half or quarter of the surface of one side (see also the purple blocks in Fig. 1(a)). The blocks use six inductive wire loops, one loop on every face of the block, allowing for 3D constructions, instead of the 2D layouts allowed for in the related works. The wire loops allow for short distance (face-to-face) communication between blocks. Bits of data are transferred by modulating the bit signal on a 1Mhz carrier. The loops are wound according to Fig. 2, to also allow half-sided and quarter-sided communication. Stacking the blocks pyramid wise, three of even five different blocks can talk to each other on the same loop connection. A decentralized communication protocol allows the blocks to know when they are



(a) Winding pattern (b) Inside of a block

Fig. 2. Implementation of the wire coils used for communication

grouped with other blocks of the same color. Therefore, in contrast to related work, this communication does not require additional communication with a central host.

5 Discussion and Evaluation

We designed and built blocks that can be used for “regular” play, but that also implicitly support the development of prenumerical skills of preschool children. In a small, first evaluation, several pairs of children (aged 5-6) played with the blocks, and their play behaviour was observed (see also Fig. 1(b)). Questions of interest were whether the children understood the interaction concept, understood the counting mechanism, used the building blocks also for “normal” construction, and whether they mentioned the counting aspects in their play. Although the evaluation was preliminary, all of these questions could be answered affirmatively from the pilot observations, leading us to believe that the basic concepts behind this project are viable.

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